RESEARCH DEPARTMENT

Equipment for the statistical analysis of programme meter deflexions

TECHNOLOGICAL REPORT No. EL-4

UDC 534.86:621.317.326 1967/12

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

EQUIPMENT FOR THE STATISTICAL ANALYSIS OF PROGRAMME METER DEFLEXIONS

Technological Report No. EL-4
UDC 534.86: 1967/12
621.317.326

J.R. Chew, B.Sc.(Eng.), M.I.E.E.
A.A. Harris

D. Maurice
for Head of Research Department

This Report is the property of the British Broadcasting Corporation and may not be reproduced in any form without the written permission of the Corporation.

This Report uses SI units in accordance with B.S. document PD 5686.

Technological Report No. EL-4

EQUIPMENT FOR THE STATISTICAL ANALYSIS OF PROGRAMME METER DEFLEXIONS

Section	Title	Page
	SUMMARY	1
1.	INTRODUCTION	1
2.	DESCRIPTION OF EQUIPMENT	1
3.	COMPUTER PROGRAMME	3
4.	METHOD OF USE	3
5.	CONCLUSIONS	4
6.	REFERENCES	4

April 1967

Technological Report No. EL-4
UDC 534.86: 1967/12
621.317.326

EQUIPMENT FOR THE STATISTICAL ANALYSIS OF PROGRAMME METER DEFLEXIONS

SUMMARY

The apparatus described examines the fluctuating deflexions of a programme meter by arranging that an image of the moving pointer falls, according to its position, upon different members of a suitable array of photo cells.

The positions of the cells can be set relatively to the image of the scale of the instrument to record data according to the scale region of greatest interest. Data from photo-electric cells is coded in a modified binary code and punched in paper tape for subsequent analysis by a digital computer.

1. INTRODUCTION

The work of assessing the performance of a programme meter can be divided into two parts. The first part is to measure the accuracy of the indication when steady state signals are applied. The second is concerned with the indications produced on application of fluctuating signals, such as are encountered in normal use. In the latter case the charge and discharge time-constants of the electrical circuits within the instrument are involved, as are the ballistic constants of the meter movement itself. It is with apparatus used for the second class of measurements that this report is concerned.

Dynamic testing of programme meters has in the past been carried out by applying some formalised representation of a programme transient, for example a "unit step" or a tone burst, and observing the response of the meter to this stimulus. Although this procedure is entirely suitable for production testing of instruments of an approved type, its application for type approval is by no means easy.

The effective time-constant of a programme meter is made up of a combination of electrical and mechanical constants, and with certain modern types of meter the overall time-constant is dependent upon programme level. As a result, the performance of the instrument in response to fluctuating signals cannot, in general, be calculated or predicted from a simple measurement of the type described above.

The device described in this report was designed to permit dynamic testing of programme meters by the application of real programme.

2. DESCRIPTION OF EQUIPMENT

The apparatus consists of two parts, an optical head and a logic unit, as shown in Fig. 1. A func-

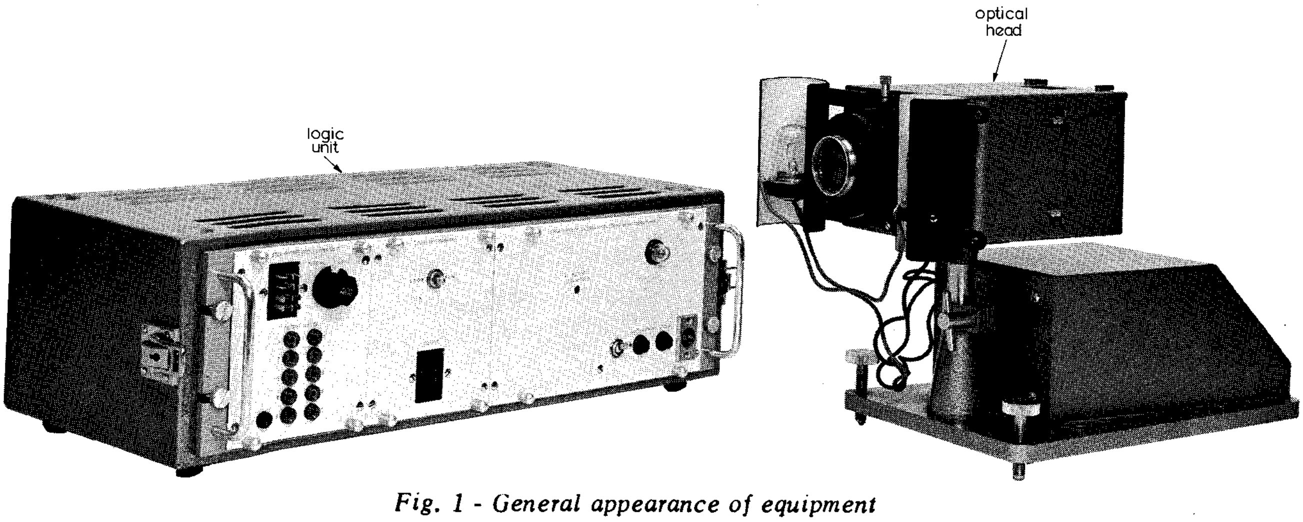

Fig. 1 - General appearance of equipment

tional drawing of the optical head is shown in Fig. 2. It can be seen that the meter under test is illuminated by a pair of lamps and an image of the meter face is projected, by a lens, on to a screen inside the head. Set in a curved slot in the screen are ten small photocells, the positions of which can be adjusted to any required points on the image of the meter scale. Each photocell produces a momentary change of voltage as the cell position is crossed by the image of the meter pointer. The pulses produced by the photocells are processed in the logic unit.

A schematic diagram of the logic unit is given in Fig. 3. The voltage pulses from the photocells are amplified and shaped by the "cell output processors", designated C.O.P., to produce suitable operating pulses for the logic circuits which follow. The cell output processors are also switchable to produce the required polarity of logic pulses from meters with either light or dark pointers.

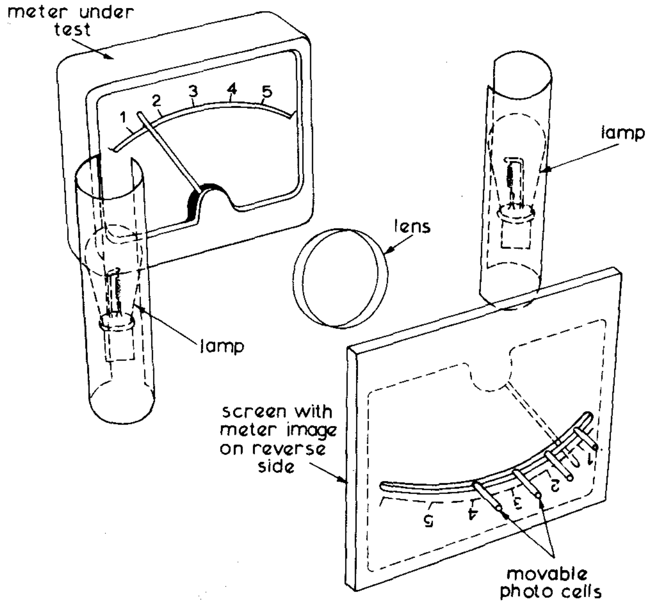

Fig. 2 - Functional diagram of optical head

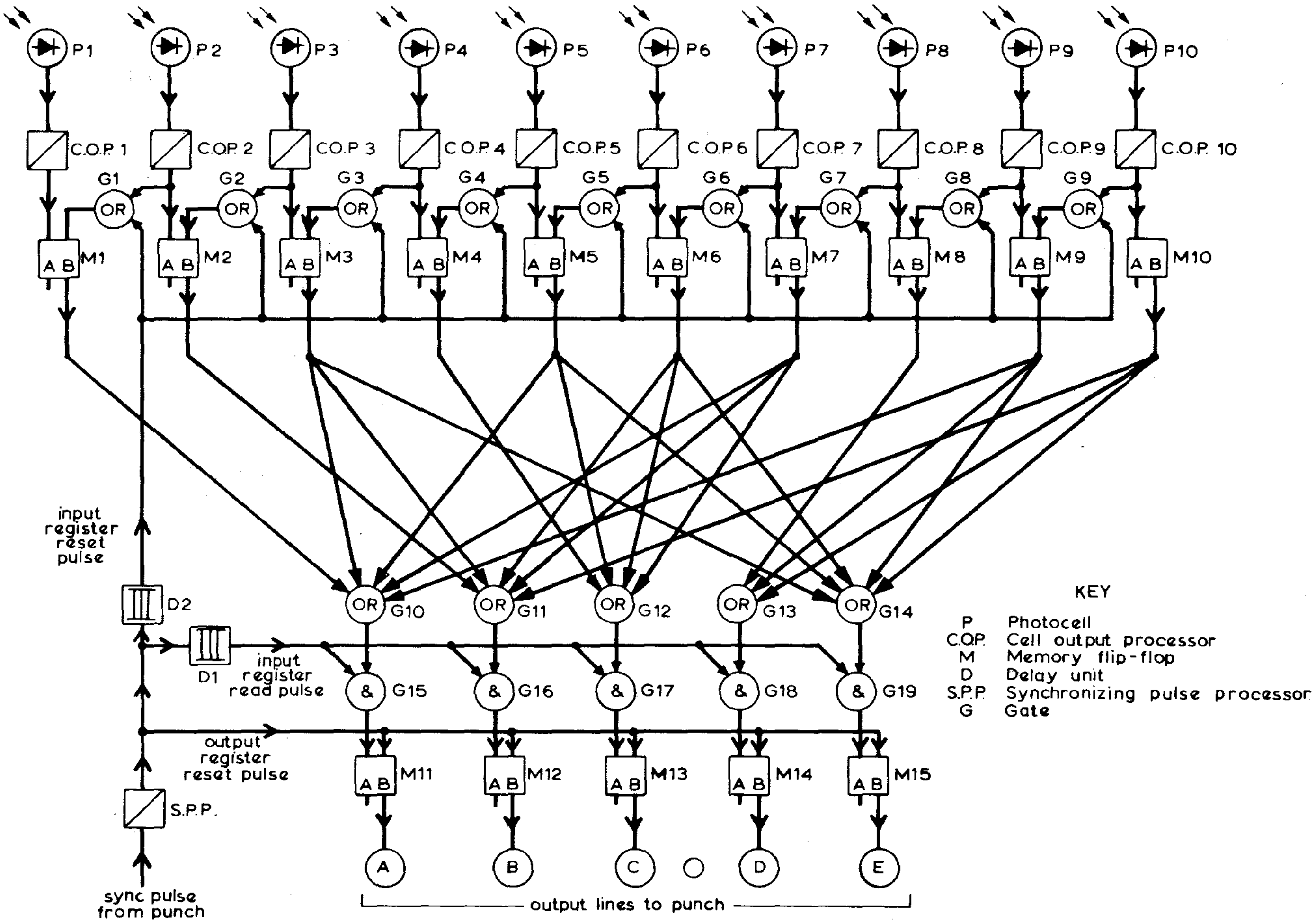

Fig. 3 - Schematic diagram of logic unit

In order to provide output of data on punched tape the information must be presented to the punch in synchronism with the tape punching cycle and held for a period of time determined by the design of the punch. The data is, however, acquired by the photocells at randomly spaced times. It follows, therefore, that the data must be stored temporarily in the logic unit until required. An "input register" of ten bistable elements (M1 to M10) is provided for this purpose. A pulse from the n^th^ photocell sets the associated bistable element to produce a logic "1" condition at its output terminal "B" and simultaneously re-sets the (n - 1)st bistable element to logic "0" at its output terminal. Thus, when the meter pointer has risen up the scale to pass the n^th^ photocell, the "n"^th^ bistable output will be the only one in the logic "1" state; on the return of the pointer past the n^th^ photocell, this output is re-set to "0" by a pulse from the punch. The output from the "input register" is coded in a parity-checked* modification of binary code, for application to a five-hole tape punch, by connexions to the coding "OR" gates (G10 to G14).

Voltages being applied to the punch signal lines are held by an "output register" consisting of five bistable elements (M11 to M15). The time at which data is transferred to the output register is controlled by a synchronizing pulse from the punch via a set of interrogating "AND" gates (G15 to G19). The resetting of both registers is also controlled by the punch synchronizing pulse. The delay units D1 and D2 ensure that the relative timing of the "read" and "reset" pulses is correct.

For the present purpose the punch is run at 100 characters per second and this is the rate of sampling the data and also of re-setting the registers. This sampling rate has been found entirely adequate to describe the movements of programme indicator pointers even under the most severe transient conditions.

3. COMPUTER PROGRAMME

The equipment described above is purely data handling equipment which serves as a means of applying the data to the computer. The analysis performed on the data is determined entirely by the computer programme. The present programme is written to perform two kinds of analysis, (*a*) to integrate the time that the pointer spends within certain specified regions of the scale, and (*b*) to count "peaks" - i.e. occasions on which the pointer deflexion passes through a maximum - and to classify them according to the scale regions in which they occur.

In dealing with the first kind of analysis, a period of time in which the pointer image pauses between two photocells results in a number of blanks being registered on the tape. The programme has to be such as to construe these blanks as repetitions of the last-occurring input.

The degree of resolution intrinsic in the data is limited by the spacing chosen for the photocells. An output from the n^th^ photocell, for instance, followed by a number of blanks defines the pointer image position only as lying somewhere between the (n - 1)st and (n + 1)st cells.

Similar limitations arise as to the accuracy with which a peak can be defined. A sequence of punched characters such as ...n, (n + 1), n..... defines a peak, of height at least one class width and peak value (n + 1), but a sequence of characters such as n, (n + 1), blank, (n + 1), n, defines the peak deflexion only as lying between the (n + 1)st and (n + 2)nd cells.

4. METHOD OF USE

In order to test a programme meter, using the apparatus, one of two methods may be adopted. The performance of the instrument under test may be compared with that of a known programme meter, applying the same programme excerpts to each instrument successively. The statistical deflexion distributions of the two instruments may then be examined and the differences found. Alternatively, a piece of programme material of known signal level distribution* may be applied to the instrument under test and the meter deflexions analysed by means of the present apparatus. The distribution curve of pointer deflexions may then be compared with the known distribution of levels in the applied programme.

By way of illustration, Figs. 4 and 5 show such distributions. The analysis was performed using a short passage from Mozart's "Don Giovanni". Fig. 4 shows the statistical distribution obtained both by meter indication analysis and by signal level analysis, in terms of the time for which a specified level was exceeded. Fig. 5 shows corresponding curves in terms of the number of peaks exceeding a specified level. The programme meter used in the above examples was a BBC programme meter type PPM/2, an instrument of rather old design in which the electrical time constant is independent of programme level and the overall dynamic characteristics largely independent of the ballistics of the meter. In this case, the two curves in each figure agree - as is to be expected - within the limitations imposed by the finite number of photocells.

---

* Parity checking is a process, involving the use of an extra digit, by which errors introduced by mis-operation of a tape punch may readily be recognised as such by the computer.

* An apparatus has been described elsewhere[1] by means of which a statistical analysis of signal levels in a given piece of programme material may be performed.

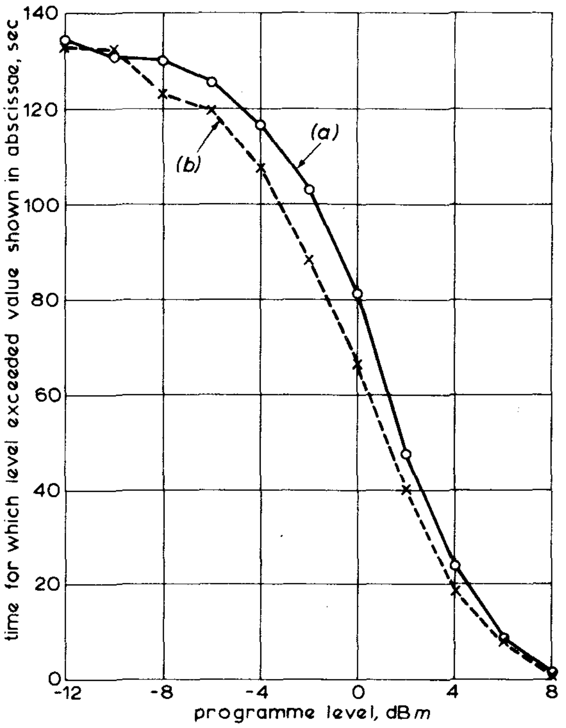

Fig. 4 - Cumulative distribution of indicated programme level

Duration of time for which specified level is exceeded

(*a*) ——— Meter indication analysis
(*b*) – – – – Signal level analysis

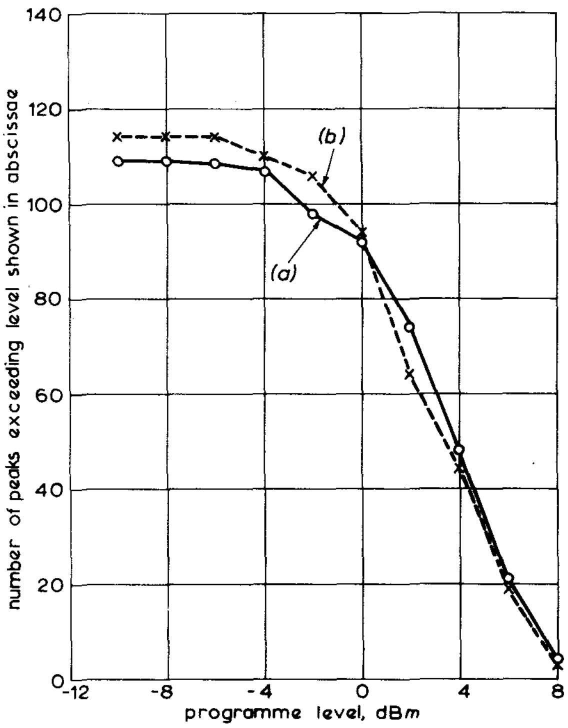

Fig. 5 - Cumulative distribution of indicated programme level

Number of peaks exceeding specified level

(*a*) ——— Meter indication analysis
(*b*) – – – – Signal level analysis

5. CONCLUSIONS

The apparatus described facilitates measurement of the dynamic performance of programme meters using real programme material. The statistics of the meter indications may be compared with those of a known input or, alternatively, the indications provided by one meter may be compared statistically with the indications of another meter, of known characteristics, using the same programme material.

6. REFERENCE

1. New equipment for the statistical analysis of sound programme levels. BBC Research Department Report No. L-070, Serial No. 1966/65.

JMP

Printed by BBC Research Department, Kingswood Warren, Tadworth, Surrey